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A NEW METHOD OF MEASURING THE DEGREE OF VACUUM IN PACKED CAN.

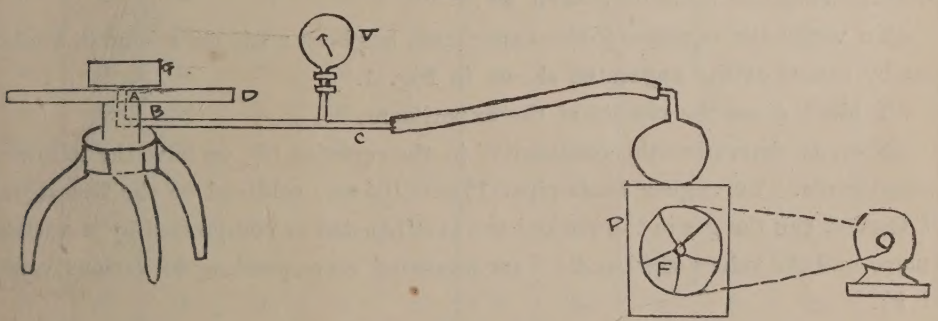
By

Kazumi Isii.

The Packed can its form when an algebraical sum of the total pressure of gas ramaining in the Packed can and of the saturation-pressure of liquid contained within at the temperature at the time when we go to examine the Packed can and of other forces is equal to the external pressure. By " others forces " just stated I mean the forces due to the elasticity of the can plate and the weight of the content. Therefore if we reduce the external pressure slowly, the system of forces becomes to be unable to retain the equllibrium and the Packed can suddenly expands.

In this case, the internal volume of the Packed can increase and the pressure of the gas decreases and at the time when all the forces above stated balance the expansion of the Packed can ceases.

Fig. 1.



P: vacuum pump
V: vacuum gauge
G: Packed can

If we denote the value of the degree of vacuum of the Packed can in the natural state (*i.e.*, the state not acted upon by any other forces) and in an expanded state by V_1 and V_2 respectively, and denote the reading of the vacuum gauge V (Fig. 1.) at the instance of expansion and contraction by V' and V'' respectively, we get the equation.

$$(76-V_1)+W-E=76-V' \quad \ldots\ldots(1)$$

$$(76-V_2)+W+E'=76-V'' \quad \ldots\ldots(2)$$

Where E and E' denote the pressures due to the elasticity of the can plate at the instances of the expansion and contraction respectively and W, the pressure due to the weight of the content.

(2)+(3) $$-(V_1+V_2)+2W-(E-E')=-(V'+V'')$$

$$V_1+V_2=(V'+V'')+2W-(E-E') \quad \ldots\ldots(3)$$

Put $$V_2-V_1=\varepsilon$$

We get $$V_1+V_1+\varepsilon=(V'+V'')+2W-(E-E')$$

$$V_1=\frac{V'+V''}{2}-\left\{\frac{E-E'}{2}+\frac{\varepsilon}{2}-W\right\} \quad \ldots\ldots(4)$$

Put $$\frac{E-E'}{2}+\frac{\varepsilon}{2}-W=C$$

Then $$V_1=\frac{V'+V''}{2}-C \quad \ldots\ldots(5)$$

Where C is a constant depending upon the kind of Packed can. If we know the constant C, the degree of vacuum may be calculated from the equation (5) by measuring the value of V' and V''.

To verify the equation (5) an experiment has been made on a kind of Packed can by means of the apparatus shown in Fig. 1.

Table 1 gives the results of the experiment.

Now, to determine the constant C in the equation (5), we have the following experiments. Through a brass-pipe, 15 cm × 0.5 cm, soldered on the lateral wall of Packed can the gas in the Packed can is exhansted or compressed by a vacuum pump, and the values of V' and V'' are measured corresponding to various values of V_1.

Fig. 2 shows the relation between V_1 and $\frac{V'+V''}{2}$ thus attained.

From Fig. 2 we know easily that the equation (5) is satisfied and that C is nearly equal to 7.0.

Then in this case, the relation between V_1 and $\frac{V'+V''}{2}$ is expressed by the equation (6).

$$V_1=\frac{V'+V''}{2}-7.0 \quad \ldots\ldots(6)$$

第　一　表

Table I

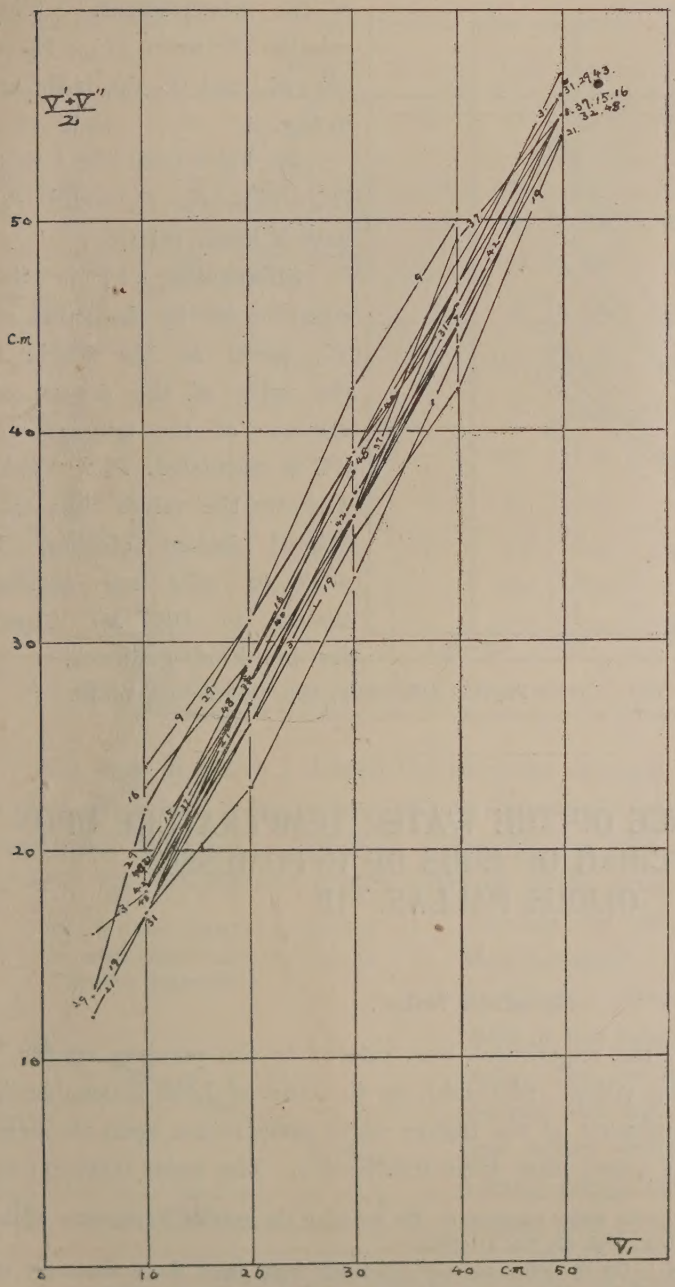
No.	V'	V''	$\frac{V'+V''}{2}$	V_{25}	V_0	No.	V'	V''	$\frac{V'+V''}{2}$	V_{25}	V_0
1	20 cm	17 cm	19 cm	12 cm	20 cm	25	29 cm	20 cm	25 cm	18 cm	25 cm
2	35	32	34	27	34	26	33	19	26	19	26
3	29	26	28	21	28	27	30	23	27	20	27
4	35	29	32	25	32	28	29	27	28	21	28
5	25	20	23	16	24	29	27	20	24	17	25
6	6	4	5	−2	7	30	50	41	46	39	45
7	25	22	24	17	25	31	27	22	25	18	25
8	31	23	27	20	27	32	34	19	27	20	27
9	36	22	29	22	29	33	27	22	25	18	25
10	22	18	20	13	21	34	36	24	30	23	30
11	37	27	32	25	32	35	40	32	36	29	35
12	24	20	22	15	23	36	41	36	39	32	38
13	32	22	27	20	27	37	34	32	33	26	33
14	38	32	35	28	35	38	43	37	40	33	39
15	39	28	34	27	34	39	29	22	26	19	26
16	45	28	27	30	36	40	40	32	36	29	35
17	37	24	31	24	31	41	32	27	30	23	30
18	36	23	30	23	30	42	32	24	28	21	28
19	27	22	25	18	25	43	34	24	29	22	29
20	35	24	30	23	30	44	17	7	12	15	23
21	31	21	26	19	26	45	26	21	24	17	25
22	24	19	22	15	23	46	34	27	31	24	31
23	36	33	35	28	35	47	35	27	31	24	31
24	18	16	17	10	18	48	40	28	34	27	34

第　二　表

Table II

No \ Temp	9°	25°	40°	No \ Temp	9°	25°	40°
	cm	cm	cm		cm	cm	cm
1	—	12	5	25	26	18	10
2	—	27	16	26	27	19	10
3	—	21	12	27	30	20	10
4	—	25	16	28	—	21	—
5	—	16	5	29	—	17	—
6	—	−2	—	30	—	39	—
7	—	17	5	31	—	18	—
8	30	20	12	32	—	20	—
9	—	22	7	33	—	18	—
10	—	13	6	34	—	23	—
11	—	25	16	35	—	29	—
12	—	15	—	36	—	32	—
13	—	20	10	37	—	26	—
14	—	28	20	38	—	33	—
15	34	27	17	39	—	19	—
16	41	30	—	40	36	29	—
17	34	24	10	41	31	23	13
18	30	23	12	42	29	21	—
19	29	18	1	43	30	22	—
20	—	23	—	44	13	15	5
21	26	19	10	45	28	17	6
22	24	15	—	46	34	24	—
23	34	28	—	47	32	24	16
24	23	10	8	48	30	27	—

Fig. 2.



The degree of vacuum calculated by (6) is given in V_{25}—columm of Table 1.

Let us V_0, V_{θ_0} and V_θ denote the degree of vacuum and F_0, F_{θ_0} and F_θ the maxmium tension of the liquid contained in a Packed can at the tempetature 0°C, θ_0°C and θ°C respectively. Then we have the following equation (7) and (8), neglecting F_0

$$76-V_{\theta_0}=(76-V_0)\times\left(1+\frac{\theta_0}{273}\right)+F_{\theta_0} \quad ..(7)$$

$$76-V_\theta=(76-V_0)\times\left(1+\frac{\theta}{373}\right)+F_\theta \quad ..(8)$$

and we have

$$(V_{\theta_0}-V_\theta)-(F_\theta-F_{\theta_0})=\frac{76-V_0}{273}(\theta-\theta_0) \quad ..(9)$$

In order to know whether the relation (9) is satisfied or not the degrees of vacuum are measured after 48 hours having been kept in various constant temperatures.

Fig. 3.

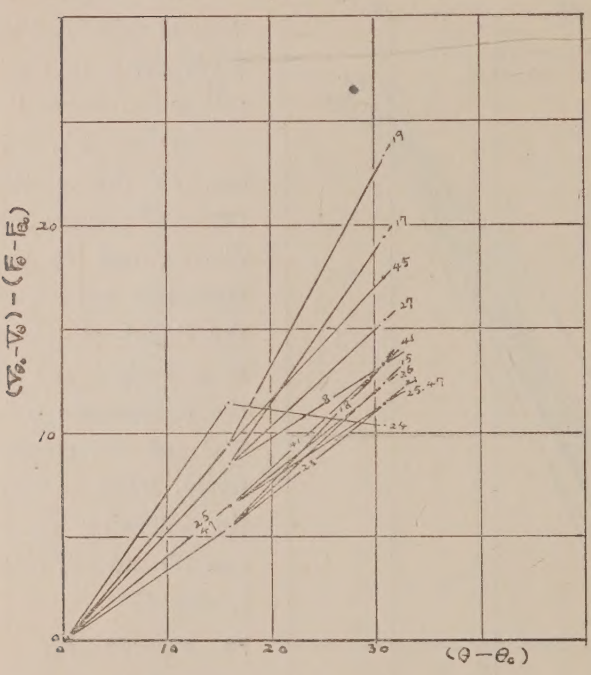


Table 2 shows the result of the measurement. The relation between $(V_{\theta_0}-V_\theta)-(F_\theta-F_{\theta_0})$ and $(\theta-\theta_0)$, is shown in Fig. 3.

We know from Fig 3 that $(V_{\theta_0}-V_\theta)-(F_\theta-F_{\theta_0})$ and $(\theta-\theta_0)$ have a linear relation.

Substituting V_θ in the equation (9) by the value of V_{25} given in the Table 1 the value of the degree of vacuum at the temperature 0°C is calculated. V_0 in Table 1 shows the values thus calculated Before closing, I wish to offer my sincere thanks to Dr. M. Tauti for his kind guidance.

October, 1927.

Physical Laboratory, Imp. Fisher. Inst. Tōkyō.

ON THE INFLUENCE OF THE WATER TEMPERATURE UPON THE HATCHING OF EGGS OF HYPOMESSUS OLIDUS PALLAS.—III

By

Nobutaka Nakai.

On 8th Feb., 1927, the experiment was, refered to the previous results,[1] carried out at the fishing village, Shitozaki, on the coast of Lake Kasumigaura in order to study the influence of the higher water temperature upon the eggs which were immediately taken after their fertilization. The water temperature

(1) Higurashi, T.: Optimum water temperature for hatching the eggs of Hypomessus olidus Pallas. (Journ. Imp. Fisher. Inst. Vol. 21, No. 1.—1925).

Higurashi, T. & Nakai, N.: On the influence of lower temperature upon the development of the eggs of Hypomessus olidus Pallas. (Journ. Imp. Fisher. Inst. Vol. 22, No. 3.—1926).

in the thermostat[2] was regulated to maintain between 13.5°–26.1°C. It lasted till 2nd March, and the following data were obtained :

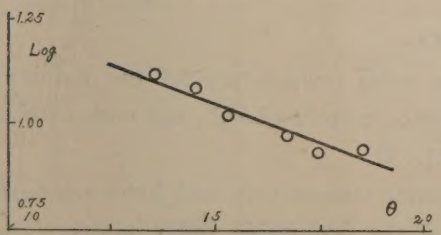
Table I. The result of the hatching.

No. of lots.	1	2	3	4	5	6	7	8	9	10
Mean temp. (t)	21.6°C.	24.0	22.1	21.0	18.5	17.5	16.7	15.3	14.5	13.5
Mean variat.	0.1°C.	0.1	0.2	0.3	0.4	0.4	0.4	0.4	0.4	0.4
Numbers of eggs, used.	420 (258)	360 (208)	350 (326)	325 (313)	331	329	291	305	317	306
Numbers of hatched larvae.	0	0	0	0	59	164	144	165	192	183
Percentage of hatching.	0	0	0	0	18%	50	49	54	61	60
Numbers of deformity.	—	—	—	—	24	22	14	18	26	31
Percentage of deformity.	—	—	—	—	41%	13	10	11	14	17
Mean hatching days. (d)	—	—	—	—	8.7	8.5	9.4	10.6	12.1	13.1
Mean variat. of hatching days. (m)	—	—	—	—	1.2	0.6	0.7	0.8	1.0	0.8
m/d×100	—	—	—	—	13.8	7.1	7.5	7.6	8.3	6.4
d×t	—	—	—	—	161°C	149	157	162	176	170

Remarks. The figures in brackets signify the numbers of eggs for the second experiment. Percentage of the deformity is calculated to the hatched numbers.

The eggs in No. 1–4 showed the irregular cleavage and were mostly destroyed within half a day or two without forming the embryos. Though another experiment was tried on 15th Feb., the result was approximately similar to the former. No. 5 being also greatly damaged at the same state of development, hatched out only 18%, of which 40% was deformed. Contrary, the far better result was obtained from No. 6, giving 50% of the hatching and 13% of deformity. No. 7–8 approached close to the former and No. 9–10 showed more or less better results. Accordingly, it is clearly recognized that the degrees of the higher limit of the favourable water tem-

Fig. I. The straight-line relation between logarithmus of hatching days and temperature.



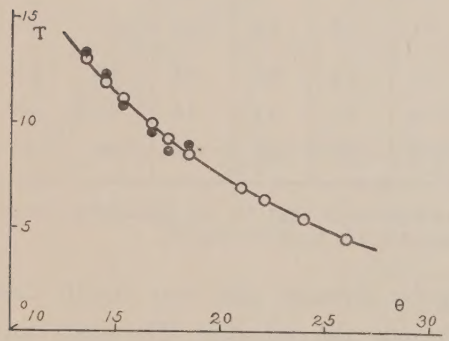
(2) Seno, H. & Tauti, M. : Apparatus for maintaining a series of constant temperatures. (Journ. Imp. Fisher. Inst. Vol. 20, No. 4.—1925).

perature for hatching eggs is, so far as this experiment goes, begins from No. 6, viz. 17.5°C. And in each case nearly 80% of the deformity was comma-shapped arva which occasionally had undulating notochord.

Table III. The relation between hatching days and temperature.

No. of lots.	1	2	3	4	5	6	7	8	9	10
Mean temper.	26.1°C	24.0	22.1	21.0	18.5	17.5	16.7	15.3	14.5	13 5
Mean hatching days. (T)	—	—	—	—	8.7	8.5	9.4	10.6	12.1	13.1
Log. T	—	—	—	—	0.94	0.93	0.97	1.03	1.08	1.12
Mean hatching days, calculated.	4.4	5.3	6.2	6.8	8.4	9.1	9.8	11.0	11.8	12.8

Fig. II. The relation between hatching days and temperature. (•....Experimental value, ○....calculated value.)



The formula of the relation between temperature and hatching days,[1] $Te^{a\theta}$ =Const., can be applied in the cases of No. 6–10 as it is explained in Table III and Figs. I–II, and the following value is obtained: a=0.085 and Q_{10}=2.33. But it is note worthy that the value in this case amounts to nearly half of those obtained in the previous experiments.

In short, the range of the favourable water temperature for hatching eggs is approximately 6.0°—17.5°C., of which the lower limit was determined in the last year. Thus the present species possesses, in comparison with other fresh-water fishes, considerably wide range of the favourable temperature for hatching eggs, and it may, perhaps, have exercised an important influence upon the wide geological distribution.

Summary.

1. The higher limit of the favourable water temperature for the hatching of eggs of Hypomessus olidus Pallas is approximately 17.5°C., and none hatches out under the temperature of more than 21.0°C.

2. The formula of the relation between temperature and hatching days, $Te^{a\theta}$=Const., can be applied in the cases of the favourable water temperature,

(1) Higurashi, T. & Tauti, M.: On the relation between temperature and the rate of development of fish-eggs. (Journ. Imp. Fisher. Inst. Vol. 21, No. 1.—1925).

第　二　表　孵化明細表

Table II. Detailed list of the hatching.

收容後ノ日數 Numbers of days after fertilizat.	No. 1		2		3		4		5		6		7		8		9		10	
	D.	H.	D.	H.	D.	H.	D.	H.	D.	H.	D.	H.	D.	H.	D.	H.	D.	H.	D.	H.
0		420 (收容) used		360 (〃)		350 (〃)		325 (〃)		331 (〃)		329 (〃)		291 (〃)		305 (〃)		317 (〃)		306 (〃)
1.0	420		356		256		51		12		13		4		—		3		—	
2.0			4		94		263		183		119		120		108		86		83	
3.0							5		3		6		1		4		16		16	
4.0							1		3		2		2		6		3		5	
5.0							—		1		—		—		—		—		—	
6.0							1		4		—		2		—		1		3	
7.0		258 (收容) used		208 (〃)		326 (〃)	1	313 (〃)	3	1 (1)	1		—		1		1		—	
7.5	(258)		(41)		(7)		1 (2)		2	25 (3)	2	46	—		—		—		—	
8.0			(167)		(319)		2 (67)		7	3 (2)	1	8 (2)	—	1 (1)	3		1		—	
8.5							(227)		2	8 (2)	1	86 (10)	1	56 (1)	1		—		1	
9.0							(14)		6	8 (4)	4	3 (2)	—	7 (1)	1		—		1	
9.5							(3)		3	2 (2)	—	9 (1)	1	48 (2)	2	38 (1)	—		—	
10.0									6	5 (4)	3	4 (2)	1	13 (4)	1	35 (2)	—		—	
10.5									6	2 (2)	1	3 (2)	2	7 (1)	1	48 (1)	—	18	—	
11.0									3	2 (2)	3	1 (1)	1	5 (2)	—	4 (2)	2	13 (1)	1	
11.5									1	—	—	—	—	1 (1)	—	19 (1)	—	87 (7)	—	2
12.0									6	—	1	2 (1)	2	4 (1)	1	8 (5)	1	2	2	7
12.5									—	—	—	—	—	—	—	7 (2)	1	29 (1)	1	97 (2)
13.0									7	1 (1)	3	—	2	—	1	3 (2)	—	12 (6)	2	3
13.5									3	—	3	1 (1)	—	2	1	1	1	16 (2)	—	54 (7)
14.0									4	—	2	—	1	—	5	—	1	1 (1)	—	3 (1)
14.5									2	1 (1)	—	—	2	—	—	—	2	7 (3)	1	9 (4)
15.0									4	—	—	—	1	—	1	—	1	—	1	1 (1)
15.5									—	—	—	—	—	—	—	—	—	2 (1)	1	—
16.0									1	—	—	1	—	—	—	—	1	3 (2)	—	2 (2)
16.5									—	—			—	—	—	—	—	—	—	—
17.0									—	—			—	—	—	—	1	1 (1)	1	1 (1)
17.5									—	1			4	—	—	—	—	—	1	1 (1)
18.0															1	—	1	—	—	1
18.5															—	—	—	—	1	—
19.0															—	1 (1)	—	—	—	—
19.5															—	—	—	—	—	1 (1)
20.0															1	—	—	1 (1)	—	—
20.5															—	—	—	—	—	1 (1)
21.0															1	—	—	—	1	—
21.5																	—	—	1	—
22.0																	2	—		

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Remarks: "D." signifies the numbers of the dead eggs and "H." the numbers of hatched larvae. In the columns of the hatched numbers, the deformed ones are closed in brackets. The numbers in brackets, in the columns of dead eggs, indicate the numbers of dead ones in the second experiment.

viz. 13.5°—17.5°C., and the following value is obtained : $a=0.085$ and $Q_{10}=2.33$.

3. Hypomessus olidus Pallas has very wide range of the favourable water temperature for the hatching of eggs, that is 6.0°—17.5°C., and it has oecologically an important bearing in relation to the wide geological distribution of the present species.

4. In each case nearly 80% of the deformity was comma-shaped larva which occassionally possessed undulating notochord.

ON THE RELATION BETWEEN THE TEMPERATURE AND THE VITALITY OF THE OYSTER PRESERVED IN THE AIR.

By

Jūzō Hori.

This study has been made to discover how long the common Japanese oysters, *Ostrea gigas*, can keep life in different temperatures after they are taken out of the sea.

The oysters used for this experiment were about five months old after attaching on tile collectors in the summer of 1926. Oyster spats, nearly uniform in size, measuring about 3.6×2.7 cm. each, were taken off carefully from the collectors on the 11th, November, 1926, and they were divided into five sets containing fifty shells, each set weighing 338 grams. Each set was put into a tin can, 8.3 cm. in diameter and 16.5 cm. in depth, with the lid closely fixed so as to prevent free ventilation in the can in order to keep the temperate in it as possible as constant. Then the cans containing the spats were put in the water (about 14 cm. deep) in the five different chambers of the thermostat which was regulated to keep up different degrees of constant temperature from 7.3 C to 18.5 C during the experiment.

Every day, the oysters were taken out from their cans and examined. It is decided that when the oysters became much weakened and finally unable to close their shells, they should be considered dead.

The following table gives the results of the experiment.

Table 1.

Mean temperature. (C)		18.5	15.9	13.2	10.4	7.3
Mean variation of temperature.		0.5	0.4	0.3	0.2	0.2
Number of oysters.		50	50	50	50	50
Date.	Number of days	Number of dead oysters.	Number of dead oysters.	Number of dead oysters.	Number of dead oysters.	Number of dead oysters.
Nov. 11	Oysters were transferred into thermostat.					
12	1					
13	2					
14	3					
15	4					
16	5					
17	6	16				
18	7	29	12			
19	8	5	25	6		
20	9		11	12		
21	10		2	8		
22	11			10	1	
23	12			8	4	
24	13			3	11	
25	14				8	
26	15			3	4	1
27	16				3	3
28	17				7	2
29	18				3	5
30	19				2	4
Dec. 1	20				3	8
2	21				2	7
3	22				1	5
4	23				1	4
5	24					3
6	25					4
7	26					2
8	27					1
9	28					1

The average days of life of the oysters, calculated from the above results are shown in Table 2. The data obtained are represented graphically in Fig. 1. (A, B.)

Table. 2.

Mean temperature. θ	18.5	15.9	13.2	10.4	7.3
Average days of life of oyster. T	6.8	8.1	10.5	15.6	21.0
log T	0.83	0.91	1.02	1.19	1.32
Calculated days of life of oyster.	6.4	8.4	11.1	14.9	20.5

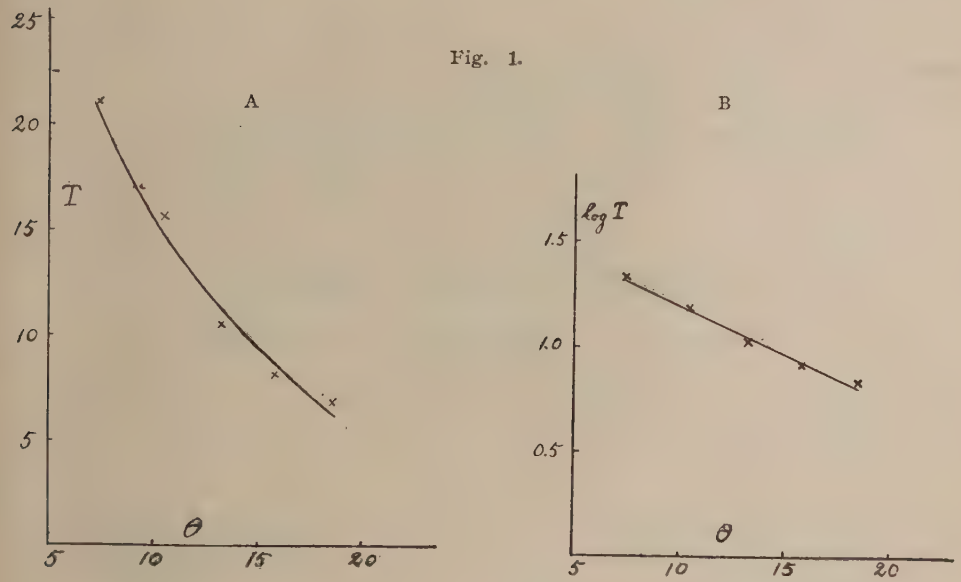
From Fig. 1, B., we can see that the relation between the temperature and the logarithms of the average days of life gives a straight line.

This relation may hold the following equation:

$$\log T+(a\log e)\,\theta=\log C$$

in which a and C are the characteristic constants of the oyster in this young stage.

Fig. 1.



The effect of temperature on the vitality of the oyster preserved in the air may therefore be expressed by the following formula:

$$Te^{a\theta}=C.$$

By the formula we obtain: $a\log e=0.045$, $a=0.104$, $C=1.64$, $Q_{10}=2.8$.

The data mentioned above represents the results in the case of the oyster spats, but generally the vitality of oysters preserved in the air differs, to a certain extent in accordance with the rate of shell growth at the time when they are taken out of the sea. Oysters with solid shell can keep life longer in the air than those growing rapidly and with a thin, delicate shell margin.

I wish to express my sincere thanks to Dr. M. Tauti for his helpful advice and also to Mr. D. Kusakabe for his kind assistance during this experiment.

Summary.

1. The relation between the temperature and the vitality of the spats of the common Japanese oyster kept in the air is as follows:

Mean temperature. (C)	18.5	15.9	13.2	10.4	7.3
Average days of life of oyster.	6.8	8.1	10.5	15.6	21.0
Calculated days of life of oyster.	6.4	8.4	11.1	14.9	20.5

2. This relation may be represented by the formula, $Te^{a\theta}=C$, in which a and C are the characteristic constant of the oyster in this young stage.

By this formula the following values are obtained:

$$a \log e=0.045,\ a=0.104,\ Q_{10}=2.8.\ C=1.64,$$

September, 1927.

Kanazawa Oyster Experimental Station
Imp. Fish. Institute.

STUDIES OF NETTING CORDS III.

THE STRENGTH OF NETTING CORDS AGAINST THE REPEATED BLOW (2).

By

Dr. M. Tauti.

In another paper the author[1] has made a study on the strength of netting cords against the repeated blow, using 3-ply-cotton cords whose thread is composed of 6 20^{s} yarns. A netting cord under test is tied to a hook at the upper end and tied to an iron plate at the lower end, and the distance between the both ties is 30 cm. A counter-weight, weighed w, is made to fall repeatedly on the iron plate from a height of h. Observing the number of blow to cause failure n and the ultimate elongation e and examining the relation of the weight w and the striking velocity v to the total energy absorbed in fracture E, it was found that, when the product wv has a definite value then the value of E is determined, *i.e.* E is a function of wv. It was also pointed out that E is determined by the average force of a blow, assuming the constancy of the time τ elapsed during an impact.

Now, let us consider m-number of same (*i.e.* the cord of same quality and equal size) netting cords put together in a bundle (not twisted), and tie that bundle to a hook at the upper end and tie to an iron plate at the lower end, and let a weight, weighed w, fall on the iron plate repeatedly from a height of h. Let the number of blow to cause failure be n and the ultimate elongation of the bundle

(1) J. Imper. Fish. Inst. XXIII, No. 1. (1927).

be e. Then the striking velocity v and the total energy absorbed in fracture may be given by the expression,

$$v=\sqrt{2gh}, \text{ and } E=nwh+we, \ (g: \text{acceleration of the gravity}).$$

And, in this case, the average force of the blow per one cord is $\frac{1}{m}\frac{wv}{\tau}$ and the total energy absorbed per one cord is $\frac{1}{m}E$.

In the case of single cord, as stated above, the energy absorbed is same whenever the average force of a blow is same. Hence, if there is no influence to each other among the m-number of cords when bound together, $\frac{1}{m}E$ should have same value when $\frac{1}{m}\frac{wv}{\tau}$ is same. We have, therefore, a relation between w, v, m and E as follows:

$$\frac{E}{m}=f\left(\frac{wv}{m}\right).$$

The m cords under consideration have in total the cross-sectional area a and the weight per unit length in total σ, both proportional to the number m. Accordingly, the last expression may be substituted to either one of the following two:

$$\frac{E}{\sigma}=f\left(\frac{wv}{\sigma}\right),$$

$$\frac{E}{a}=f\left(\frac{wv}{a}\right).$$

According to the investigation carried out by Mr. K. Kawai and Dr. T. Terada[1] on the relation between the size and the static strength of cords, the following properties of cotton cords were verified. (i) As to the cord, whose thread is composed of less than 60 yarns, the strength varies proportionally as the weight per unit length, in spite of the hardness of the twist. (ii) The strength varies proportionally as the number of yarns constructing the cord. (iii) When the cords are twisted in equal hardness, the strength is proportional to the cross-sectional area. From these facts we can conclude that as to the cotton-cord, whose thread is composed of less than 60 yarns, the m-number of cords taken together in a bundle have as the same strength, the same weight per unit length and the same cross-sectional area as a single cord, of which the number of yarns is equal to the total number of those of the m cords.

(1) J. Imper. Fish. Inst. IX, No. 6. (1914).

In the case of repeated blow, if we consider that the m-number of same cords taken together in a bundle is equivalent to a single cord which has the same number of yarns, the formulae above obtained in general are applicable to the cords of different size. Namely:—

(a) When a repeated impulsive force proportional to wv acts on a netting cord of the weight per unit length σ, the energy absorbed in fracture E is expressed by the equation (1)

$$\frac{E}{\sigma}=f\left(\frac{wv}{\sigma}\right) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

The functional form f depends upon the kind of fibre.

(b) For the cords of the cross-sectional area a twisted in an equal hardness, we have the equation (2)

$$\frac{E}{a}=f\left(\frac{wv}{a}\right) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

The functional form f depends on the hardness of twist as well as the kind of fibre.

To verify these relations, the author troubled Mr. H. Muta and 12 students to make an experiment on cotton cords of various size.

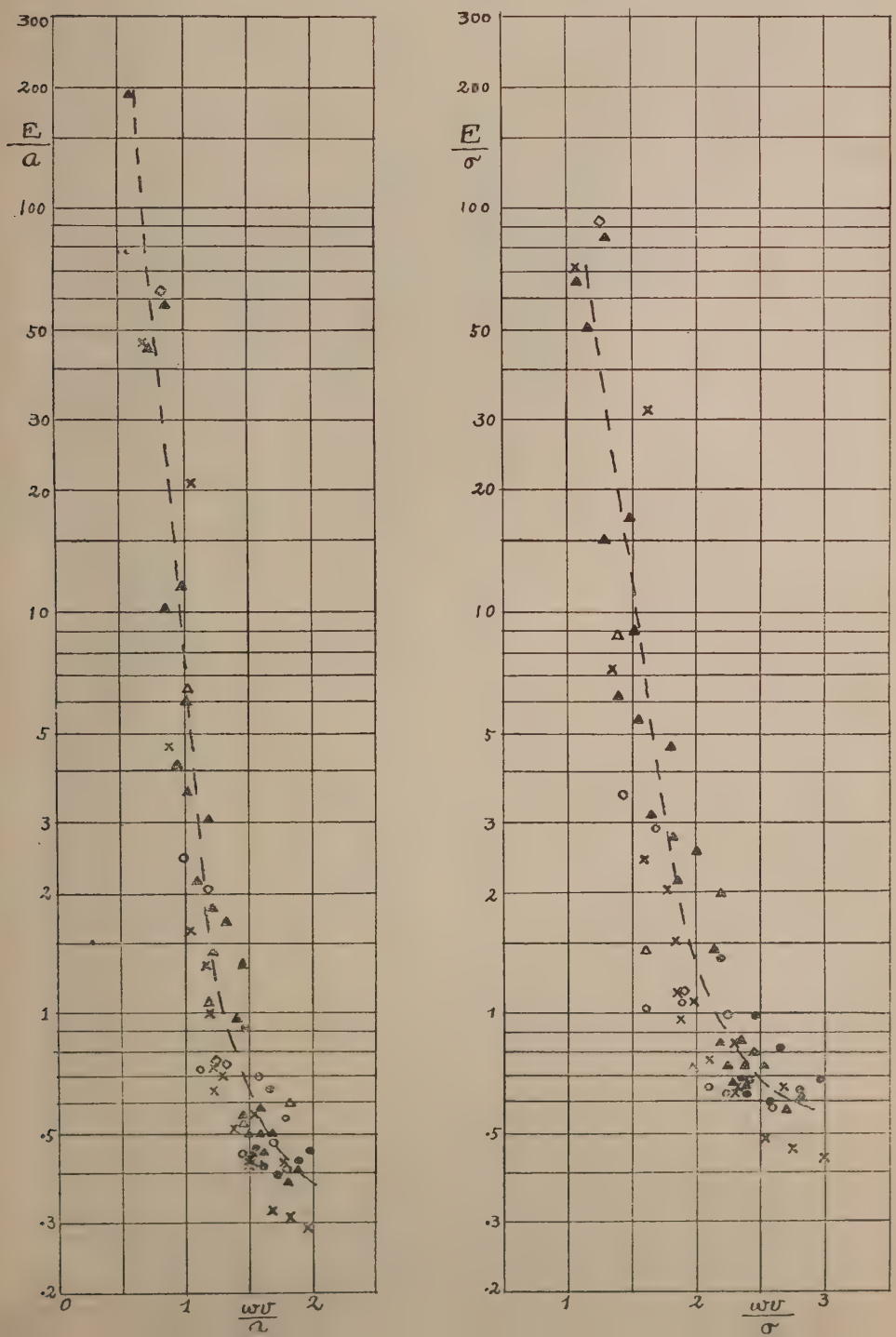
The results thus obtained and, E, v, wv, $\frac{E}{a}$, $\frac{wv}{a}$, $\frac{E}{\sigma}$ and $\frac{wv}{\sigma}$ calculated from the experimental results are shown in Table I. In this table ν denotes the number of yarns of thread.

The relations between $\frac{E}{a}$ and $\frac{wv}{a}$, and between $\frac{E}{\sigma}$ and $\frac{wv}{\sigma}$ are graphically shown in Fig. 1.

Looking at the figure, we can find that the relation given by the equation (1) and (2) are satisfied.

Conclusion. When an impulsive force obtained by a falling weight, weighed w, which is made to fall from a height of h—the velocity at the commencement of the impact v is equal to $\sqrt{2gh}$—acts repeatedly on a cord having the cross-sectional area a and having the weight per unit length σ, we take the energy absorbed in fracture E. Then; (a), $\frac{E}{\sigma}$ is determined by $\frac{wv}{\sigma}$ alone if the kind of fibre of cords is same; (b), $\frac{E}{a}$ is determined by $\frac{wv}{a}$ alone if the kind of fibre is same and the hardness of twist is nearly equal.

• 4, × 6, ▲ 8, ○ 12, △ 20, ◇ 30.


300
200
E/a
100
50
30
20
10
5
3
2
1
·5
·3
·2
0
1
2
ωv/a
300
200
E/σ
100
50
30
20
10
5
3
2
1
·5
·3
·2
1
2
3
ωv/σ

In the view of determining the relations between $\frac{E}{a}$ and $\frac{wv}{a}$, and between $\frac{E}{\sigma}$ and $\frac{wv}{\sigma}$ for cotton cords, we have calculated the average values of $\frac{E}{a}$, $\frac{wv}{a}$, $\frac{E}{\sigma}$ and $\frac{wv}{\sigma}$ from Table I, and arranged them in Table II. The broken lines in Fig. 1 show the relations thus obtained.

Table II.

$\frac{wv}{a}$	Mean value of $\frac{wv}{a}$	Mean value of $\frac{E}{a}$	$\frac{wv}{\sigma}$	Mean value of $\frac{wv}{\sigma}$	Mean value of $\frac{E}{\sigma}$
.5～ .7	.63	119.4	.75～1.00	.83	289.
.7～ .9	.81	35.6	1.00～1.25	1.13	70.5
.9～1.1	1.02	6.54	1.25～1.50	1.37	20.7
1.1～1.3	1.20	1.28	1.50～1.75	1.60	10.0
1.3～1.5	1.43	.79	1.75～2.00	1.86	1.82
1.5～1.7	1.59	.50	2.00～2.25	2.18	1.05
1.7～1.9	1.81	.44	2.25～2.50	2.36	.74
1.9～2.1	1.98	.38	2.50～2.75	2.62	.61
			2.75～3.00	2.90	.60

March, 1928. Physical laboratory, Imp. Fisher. Institute, Tôkyô.

Table I.

w kg.	h cm.	n	e cm.	E kg.m	v m/sec.	wv	$\frac{E}{a}$	$\frac{wv}{a}$	$\frac{E}{\sigma}$	$\frac{wv}{\sigma}$
				$\nu=4$ $d=.92$ mm, $a=.67$ mm^2., $\sigma=0.445$ gr/m.						
.67	11	8.0	4.3	.61	1.47	.98	.91	1.47	1.36	2.18
	12	3.6	2.8	.31	1.54	1.03	.46	1.54	.69	2.29
	13	3.0	2.7	.28	1.60	1.07	.42	1.60	.62	2.38
	14	4.6	4.9	.45	1.66	1.11	.67	1.66	1.00	2.46
	15	2.5	3.0	.27	1.71	1.15	.40	1.72	.60	2.56
	16	3.3	4.6	.37	1.77	1.19	.55	1.78	.82	2.65
	18	2.2	3.7	.29	1.88	1.26	.43	1.88	.64	2.80
	20	2.2	4.2	.31	1.98	1.33	.46	1.98	.69	2.96
			3.8							
				$\nu=6$ $d=1.17$ mm, $a=1.08$ mm^2. $\sigma=0.705$ gr/m.						
1.82	2	624.0	—	22.6	.63	1.15	20.9	1.06	31.8	1.62
	3	12.7	3.9	.76	.77	1.40	.70	1.30	1.07	1.97
	4	5.2	4.0	.45	.89	1.62	.42	1.50	.63	2.28
	5	3.0	4.6	.35	.99	1.80	.32	1.67	.49	2.53
	6	2.4	4.7	.33	1.08	1.96	.31	1.82	.46	2.75
	7	1.9	3.5	.31	1.17	2.13	.29	1.97	.44	3.00
.97	3	1724.0	—	50.5	.77	.75	46.7	.69	71.1	1.06
	5	105.0	—	5.1	.99	.96	4.7	.89	7.2	1.35
	10	7.9	—	.80	1.36	1.32	.74	1.22	1.13	1.86
	15	4.0	—	.62	1.70	1.65	.57	1.53	.87	2.32
	20	2.2	—	.47	1.97	1.91	.43	1.77	.66	2.69
.67	15	17.2	—	1.76	1.70	1.14	1.63	1.05	2.47	1.60
	18	11.6	3.9	1.43	1.88	1.26	1.32	1.17	2.01	1.77
	19	8.2	3.1	1.08	1.95	1.30	1.00	1.20	1.52	1.83
	20	4.9	3.8	.69	1.97	1.32	.64	1.22	.97	1.86
	25	3.1	3.6	.55	2.23	1.49	.51	1.38	.77	2.10
	30	2.2	—	.47	2.45	1.64	.43	1.52	.66	2.30
			3.9							
				$\nu=8$ $d=1.31$ mm, $a=1.35$ mm^2, $\sigma=0.902$ gr/m.						
1.82	2	374.1	—	13.7	.63	1.15	10.1	.85	15.2	1.28
	3	88.4	—	4.9	.77	1.40	3.6	1.03	5.5	1.55
	4	56.3	—	4.2	.89	1.62	3.1	1.20	4.7	1.80
	5	24.0	—	2.3	.99	1.80	1.70	1.33	2.55	2.00
	6	15.6	6.4	1.80	1.08	1.97	1.33	1.45	2.00	2.19
	7	4.5	5.8	.67	1.17	2.13	.50	1.58	.74	2.37
	8	4.0	5.6	.67	1.25	2.27	.50	1.68	.74	2.52
	9	2.6	5.1	.52	1.33	2.43	.38	1.80	.58	2.70
	10	2.6	4.8	.56	1.40	2.55	.41	1.89	.62	2.82
.97	3	8907.5	—	260.	.77	.75	192.	.56	289.	.83
	5	1249.7	—	60.7	.99	.96	45.	.71	67.4	1.07
	10	83.2	—	8.1	1.40	1.36	6.0	1.01	9.0	1.51
	15	13.0	5.5	1.94	1.72	1.67	1.43	1.24	2.15	1.85
	20	6.5	5.3	1.31	1.98	1.92	.98	1.42	1.45	2.14
	21	3.5	4.6	.76	2.03	1.96	.56	1.45	.84	2.18
	22	2.9	4.0	.67	2.08	2.02	.50	1.50	.74	2.24
	23	2.5	4.0	.61	2.13	2.06	.45	1.53	.68	2.29
	24	3.1	5.0	.77	2.17	2.10	.57	1.56	.86	2.33
	25	2.3	4.5	.61	2.22	2.15	.45	1.60	.68	2.39
.67	12	565.0	—	45.3	1.54	1.03	33.7	.76	50.5	1.15
	15	788.5	—	78.7	1.72	1.15	58.0	.85	87.6	1.28
	18	46.3	—	5.6	1.88	1.25	4.1	.93	.62	1.39
	20	115.5	—	15.5	1.98	1.33	11.5	.99	17.2	1.48
	25	17.3	—	2.9	2.22	1.49	2.15	1.10	3.2	1.65
	30	12.4	—	2.5	2.43	1.63	1.85	1.21	2.8	1.81
			5.0							
				$\nu=12$ $d=1.57$ mm, $a=1.94$ mm^2, $\sigma=1.350$ gr/m.						
2.80	6	7.4	4.4	1.35	1.08	3.02	.70	1.56	1.00	2.24
	7	4.2	3.9	.93	1.17	3.27	.48	1.68	.69	2.42
	8	3.1	4.0	.80	1.25	3.50	.41	1.80	.59	2.59
1.82	8	26.6	4.3	3.94	1.25	2.27	2.03	1.17	2.91	1.68
	10	7.6	3.9	1.45	1.40	2.54	.75	1.31	1.07	1.88
	12	3.7	3.2	.88	1.54	2.80	.45	1.45	.65	2.08
	14	3.0	3.5	.83	1.66	3.01	.43	1.55	.62	2.23
.97	20	24.2	3.9	4.74	1.98	1.92	2.45	.99	3.51	1.42
	25	5.6	3.4	1.39	2.22	2.15	.72	1.11	1.03	1.60
			3.8							
				$\nu=20$ $d=1.97$ mm, $a=3.05$ mm^2, $\sigma=2.264$ gr/m.						
2.80	20	3.0	4.5	1.81	1.98	5.55	.60	1.82	.80	2.45
1.82	15	72.3	5.1	19.9	1.72	3.12	6.5	1.03	8.8	1.38
	20	8.7	4.9	2.23	1.98	3.60	1.06	1.18	1.43	1.60
	30	2.8	4.1	1.61	2.43	4.42	.53	1.45	.72	1.96
			4.7							
				$\nu=30$ $d=2.63$ mm, $a=5.48$ mm^2, $\sigma=3.609$ gr/m.						
2.80	30	4.7	4.8	4.08	2.43	6.82	.75	1.25	1.13	1.89
1.82	30	613.	4.9	335.	2.43	4.43	62.	.81	93.	1.23
			4.9							

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